



URMIA, LAKE

Urmia, Lake, called Lake (Daryāča-ye) Režā'īya in the Pahlavi period, a salt lake in northwest Iran separating the provinces of West Azarbaijan (Aḏarbāyjan-e Ġarbi) and East Azarbaijan (Aḏarbāyjan-e Šarqi). Lake Urmia is the largest lake in the Middle East and the second largest salt lake on earth. It is located 4,183 feet above sea level, lat 37° to 38.5° N, long 45° to 46° E. It is approximately 140 km long in a north-south direction and about 85 km wide in its east-west extension with a surface area of 5,000 to 6,000 km². Depending on the time of observation and measurement, the height of the water table varies between 1,295 m. above mean sea level (msl; Löffler, 1956, p. 214 [probably an incorrect measurement]) to 1,280 m. (Schweizer) and 1,271 m. above sea level (Pengra). Earlier, though necessarily rough, measurements substantiate these observations. While Robert Güthner (1899, p. 505) speaks of an overall basin size of "19.370 square miles, of which 1795 square miles are at present occupied by the Lake of Urmi and its Islands" (that is, 50,168 km² and 4,649 km² respectively), de Macquenem (p. 129) speaks of only a 35,000 km² basin size. Kaehne (p. 104), on the other hand, calculates an overall size of the Lake Urmia catchment area of approximately 52,500 km², of more than 13,000 km² for the immediate lake basin, and of 5,775 km² for Lake Urmia itself. All these figures indicate the lake's great fluctuations in time and space and its constantly changing size and depth, which is also responsible for the variations of its salt content and biogeochemistry.

Geographical environment. Fluctuations of the lake's size and oscillations of its water table are closely connected with the geographical environment of its



basin. Like so many other drainage basins in Iran, Lake Urmia is the center of an internal drainage basin and distinctly separated from other basins by a high mountain environment on all sides. Size of the drainage basin and, therefore, also of the catchment area of Lake Urmia is about 51.000 km². The overall physiography is that of an almost circular geological basin structure with the lake in its central part. As such, it receives a number of tributaries of different lengths and water-carrying intensities. The longest of them is the Zarrinarud with a length of approximately 230 km, entering the lake from the south. The second largest is the Āji Ćāy with a length of approximately 140 km. According to Ghaheri et al. (p. 20), a total of 21 permanent or seasonal rivers as well as 39 periodic ones discharge into the lake (Figure 1).

Permanence, seasonality, and/or periodicity of the tributaries to Lake Urmia are distinctly influenced by both topography and climate. While most of the rivers have only small catchment areas, separated from each other by eroded crests and ridges (Figure 1), the overall height of the Lake Urmia basin and its surroundings are responsible for the climatic parameters of the basin. While the basin itself receives less than 300 mm rainfall per year, the surrounding plains and mountain ranges with many heights up to more than 3,200 meters (Figure 1) are covered by heavy winter snowfall, which is the basis of an increased runoff of the lake's tributaries in spring and early summer. The overall climate situation of the Lake Urmia basin is characterized by cold winters and long, dry summers. In winter, the temperature can get as low as -20° centigrade or even lower, while in summer it may easily surpass 35°. Altogether, the meteorological year of the basin can be separated into a predominantly moist and humid winter season lasting from November to April/May and an arid summer season from May to October. Average rainfall within the basin has been calculated to be 235 mm (average of the time period 1967-2006), with a distinct decrease by 40 mm for the ten-year period of 1997-2006, a clear indication of climate change and typical for similar findings in northwestern Iran (Pengra, p. 6).

Hydrology. Topography and climate are decisive factors for the hydrology of Lake Urmia. Analysis of its annual cycle demonstrates that the beginning of snowmelt in the mountains in late spring leads to increased discharges of the rivers and to rising water levels of the lake. These annual fluctuations of the lake surface may vary between 20 cm to 50-60 cm in the years of above-average precipitation. The overall annual inflow into Lake Urmia is considered to be 6,900 million m³ of water, of which 4,900 million m³ are

contributed by rivers, 500 million m³ by floods, and 1,500 million m³ by precipitation over the lake (Ghaheri et al., p. 19). Deviations of these averages cause slightly higher or lower annual levels of the lake surface, and they are also responsible for the fact that a varying number of islands come into existence when the water level is low (Ghaheri et al., p. 20).

In contrast to the annual fluctuations of the lake surface, long-term variations of the lake are much more dramatic. They are the causes of heavy ecological concern. As mentioned already, the secular fluctuations of the lake are considerable (for very rough geological details, see Kaehne, pp. 122-23; [Figure 3](#)). Not taking into account the geological history of the lake, which according to Günther Schweizer is documented by a glacial terrace system as a result of much higher lake levels of 30 m, 60 to 65 m, 80 to 85 m, and 115 m above the water level of 1968 (i.e., 1,280 m), its more recent fluctuations with amplitudes of up to 10 meters are alarming. They are indicators not only for the hydrological vulnerability of the lake, but in the long term also for the continuous diminution of the body of water and the reduction of the mean (6-8 m) and maximum (13-15 m) depth of the lake ([Figure 2](#)).

Reasons for these fluctuations are manifold. While the annual and more or less regular variations are due to the temperature and precipitation regimes of the Lake Urmia basin and its surroundings, the longer-term oscillations must be interpreted as reactions to short-term climate changes:

Because Lake Urmia is a terminal lake with no significant water outflow, the only way water leaves the lake is by evaporation. Therefore, if the lake declines it is either by increased evaporation or a decrease in water coming into the system. The Zarrineh Rood River is the largest of the thirteen main rivers discharging into Lake Urmia, which are the source of the majority of the Lake's water budget. Additional input comes from rainfall directly over the lake, floodwater from the immediate watershed and a very small fraction from groundwater flow. (Pengra, p. 6)

According to the same source, 65 percent of the dramatic decline of Lake Urmia in recent years is due to reduced river discharges, decreased precipitation over the lake (10 percent), and construction of dams (25 percent) for irrigation purposes, while the annual evaporation rate of the lake is considered to be about 1 m (Ghaheri et al.). Evaporation rates, however, cannot be held responsible for the tremendous secular oscillations of this endorheic lake. As indicated in [Figure 2](#), variations of the lake surface have



been observed (although obviously not regularly measured with standard equipment) over the past 100 years (an interesting compilation of sea level fluctuations of Lake Urmia in the 19th century and up to 1914 is recorded by Kaehne, pp. 131-32). It is fact, however, that within a period of 15 years the surface elevation of the lake dramatically decreased by approximately 7 m from its peak in the mid-1990s (1,278 m above msl) to 1,271 m above msl in 2010. This dramatic decrease must have dramatic impacts on the salt content of the endorheic lake and, as a result, on the biology of this unique body of water.

Physico-chemical features. A very specific feature of Lake Urmia is its salinity, typical for many endorheic lakes in arid and semi-arid environments. In one of the earlier in-depth investigations of Lake Urmia, Heinz Löffler (1956, p. 215) recorded concentrations of 366 grams of salt per liter. However, these measurements also seem to reflect very special conditions. Chemical analyses of more recent data indicate lower values. While 300 g/l almost reaches saturation levels—salt concentrations almost 8 times higher than oceanic sea water—average concentrations of Lake Urmia seem to be 217-35 g/l (Ghaheri et al., p. 20) with sodium and chloride as dominant ions. Yet, these concentrations vary and are also dependent on the annual water cycle of the lake; the concentrations are lower in spring with higher sweet water discharges of the rivers, and they increase in summer with the sinking water table and higher temperatures and evaporation (Löffler, 1961, pp. 338-45). Due to the fact that the surrounding mountain ranges of the Lake Urmia basin are characterized also by salt-bearing strata and by volcanoes, both gypsum and salt deposits have been accumulated in the bottom of the lake (Löffler, 1961, p. 339): “The total salt mass is estimated as 12×10^9 tons, most of which has ultimately been derived from river inputs” (Ghaheri et al., p. 20). High evaporation rates over the lake maintain and even increase the salt content, depending on the water table.

Biological and environmental aspects. The salinity of Lake Urmia and the considerable fluctuations of the lake make it a unique hydrological and ecological phenomenon. While fish populations and mollusks do not exist in this hypersaline environment, Lake Urmia is home of a number of diatoms, phytoplankton (algae). and bacteria (see Löffler, 1956, p. 216; idem, 1961, pp. 340 ff.), while the coastal strips are wetlands of varying extent and partly covered by a salt-tolerant littoral vegetation. In spite of the overall reduced living conditions for flora and fauna, Lake Urmia provides an important



habitat for the aforementioned species. Löffler (1961, p. 342-45) lists a great number of diatoms, rotatoria, and green algae (esp. *Euglena*) that constitute the lower end of a food chain in which shrimp populations play a crucial part. Especially the brine shrimp *Artemia urmia* is an important food link for migratory birds such as pelicans, flamingos, and different kinds of egrets and ducks. On the whole it is evident that the intensity of bird migration is dependent on the primary production of the lake and especially on the availability of salt-adjusted brine shrimps. The increasing salt content of Lake Urmia water is a major threat to the continuation of this highly sensitive food chain.

Present state and future of Lake Urmia. Today, Lake Urmia represents a highly endangered ecosystem, the future of which is being compared to the catastrophic fate of the Aral Sea in Central Asia. While the present shrinkage of the lake is dramatic, the consequences of this development are even more alarming (for a detailed analysis, see Pengra, figs. 3, 5, and 6 with satellite images from 1963 to 2011; see also Alesheikt et al.). Reasons for the permanent reduction of the lake surface are, above all, an increasing use of the tributary river waters for irrigation purposes either by diversion of the water directly into the fields or by construction of dams and retention basins. An immediate consequence of the lake's retreat is the exposure of increasingly large sections of the former lakebed and their salt crusts to the forces of wind. At present, more than 400 km² of sodium chloride-covered salt flats surround the lake and are being blown out. Wind erosion causes salt storms, and the salty particles are deposited on adjoining agricultural lands, diminishing their fertility and productivity. Additionally, many rivers are polluted by untreated urban household and industrial waters, causing additional problems both for the ecology of the lake and the human population of its shore regions. Finally, the construction of a causeway and bridge has added further problems to the hydrology of the lake. This structure, using the island/peninsula (depending on the height of the water table) of Šāhi (Šebh-e Jazira-ye Šāhi) as a bridgehead, is a major obstacle for the already reduced circulation of water and divides the lake into two parts of almost equal size. It is interesting to note that before World War I there was a commercial shipping fleet on the waters of Lake Urmia. Günther (1899, p. 512) reports that "the fleet at present on Lake Urmi consists of three ships of about 20 tons burden, round bottomed, round bowed, but with flat sterns and a great capability of rolling." Their efficiency, however, seems to have been rather limited since these sailing boats were heavily dependent on regular and rapidly changing winds. The



consequences of Lake Urmia's shrinking and potential countermeasures to re-establish its former size are indicated by Pengra (pp. 7-9). The latter are, however, rather unrealistic (for instance, diversion and pumping of Caspian Sea waters to Lake Urmia). Instead, construction of water treatment plants along the main rivers and deconstruction of dams, barrages, and water channels in order to restore a natural river flow would be a better option with, however, negative impacts on the agricultural activities in the Lake Urmia basin.

BIBLIOGRAPHY

M. Abbaspour,. and A. Nazaridoust,. "Determination of Environmental Water Requirements of Lake Urmia, Iran: An Ecological Approach," *International Journal of Environmental Studies* 64/2, 2007, pp. 161-69.

A. A. Alesheikt, A. Ghorbanali, and N. Nouri, "Coastline Change Detection Using Remote Sensing," *International Journal of Environmental Sciences and Technology* 4/1, 2007, pp. 61-66.

Samad Alipour, "Hydrogeochemistry of Seasonal Variation of Urmia Salt Lake, Iran," *Saline Systems* 2/9, 2006.

Alireza Asem, Fereidun Mohebbi, and Reza Ahmadi, "Drought in Urmia Lake, the Largest Natural Habitat of Brine Shrimp *Artemia*," *World Aquaculture* 43, 2012, pp. 36-38.

Y. Asri, and M. Ghorbanli, "The Halophilous Vegetation of the Orumieh Lake Salt Marshes, NW. Iran," *Plant Ecology*, no. 132, 1997, pp. 155-70.

Peter Beaumont, *River Regimes in Iran*, University of Durham, Department of Geography, Occasional Publications, New Series 1. Durham, 1973.

J. F. Coakley, "Urmia," in *EI²* X, 2000, pp. 896-99.

‘Abd-al-Rahmān ‘Emādi, “Nāmhā-ye Daryāča-ye Orumiya,” in Iraj Afšār and Qodrat-Allāh Rowšani Za‘farānlu, eds., *Yağmā-ye si-o dovvom: yādnāma-ye Habib Yağmā’i*, Tehran, 1991, pp. 301-9.

Environment Protection Bureau of West Azarbayan Province, *A Study for the Establishment of Natural Park on the Islands of Urmia Lake*, 3 vols., Tehran, 1992 (in Persian).

Esmā‘il E‘temādi, “Kuh-e gusfand (Quyun daği dar Daryāča-ye Urmia),” *Talāš*, no 19, 1969, pp. 74-80.

M. Ghaheri, M. H. Baghal-Vayjooee, and J. Naziri, “Lake Urmia, Iran: A Summary Review,” *International Journal of Salt Lake Research* 8, 1999, pp. 19-22.

Hossein Golabian, “Urumia Lake: Hydro-Ecological Stabilization and Permanence,” in Viorel Badescu and Richard B. Cathcart, eds., *Macro-engineering Seawater in Unique Environments*, Berlin, 2011, pp. 365-97.

Robert T. Günther, “Contribution to the Geography of Lake Urmia,” *Geographical Journal* 14/5, 1899, pp. 504-11.

Idem, “Contribution to the Natural History of Lake Urmia NW Persia and Its Neighborhood,” *Journal of the Linnaean Society: Zoology* 27, 1900, pp. 345-453.

Robert T. Günther and J. J. Manley, “On the Waters of the Salt of Lake of Urmi,” *Proceedings of the Royal Society of London* 65, 1899, pp. 312-18.

Mukhtar Hasemi, “A Socio-technical Assessment Framework for Integrated Water Resources Management (IWRM) in Lake Urmia Basin, Iran,” Ph.D. diss., University of Newcastle upon Tyne, 2012.

Sheida Jalili et al., “The Influence of Large-scale Atmospheric Circulation Weather Types on Variations in the Water Level of Lake Urmia, Iran,” *International Journal of Climatology* 32, 2012, pp. 1990-96.

K. Kaehne, “Beiträge zur physischen Geographie des Urmija-Beckens,” *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 1923, pp. 104-32.

Abdolreza Karbassi et al., “Environmental Impacts of Desalination on the Ecology of Lake Urmia,” *Journal of Great Lakes Research* 36/3, 2010, pp. 419-24.



Mas'ud Kayhān, *Joḡrāfiā-ye mofaššal-e Irān*, 3 vols., Tehran, 1931-32, I, pp. 80-84.

Guy Le Strange, *The Land of the Eastern Caliphate: Mesopotamia, Persia, and Central Asia*, Cambridge, 1905; tr. Maḥmud 'Erfān, as *Joḡrāfiā-ye tāriki-e sarzaminhā-ye kelāfat šarqi*, Tehran, 1958, pp. 171-72.

Heinz Löffler, "Ergebnisse der Österreichischen Iranexpedition 1949/50: Limnologische Untersuchungen an Iranischen Binnengewässern," *Hydrobiologia* 8/3-4, 1956, pp. 201-78.

Idem, "Beiträge zur Kenntnis der Iranischen Binnengewässer II: Regional-limnologische Studie mit besonderer Berücksichtigung der Crustaceenfauna," *Internationale Revue der gesamten Hydrobiologie und Hydrographie* 46/3, 1961, pp. 309-406 (esp. pp. 338-45, with extensive bibliography).

R. de Mecquenem, "Le lac d'Ourmiah," *Annales de Geographie*, 17, 1908, pp. 128-44.

B. Pengra, "The Drying of Iran's Lake Urmia And Its Environmental Consequences," *UNEP Global Environmental Alert Service (GEAS)*, February 2012, available at http://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=79 (accessed 1 February 2013).

'Enāyat-Allāh Rezā, "Urmia," in *Dāyerat al-ma'āref-e bozorg-e eslāmi* X, pp. 422-24.

Alfred Rodler, *Der Urmia-See und das nordwestliche Persien*, Wien, 1887, pp. 535-75.

Günther Schweizer, *Untersuchungen zur Physiogeographie von Ostanatolien und Nordwestiran. Geomorphologische, klima- und hydrogeographische Studien im Vansee- und Rezaiyehsee-Gebiet*, Tübinger Geografische Studien, Heft 60, Tübingen, 1975.

M. Zarghami, "Effective Watershed Management; Case Study of Urmia Lake, Iran," *Lake and Reservoir Management* 27/1, 2011, pp. 87-94.

M. Zeinoddini, M., Tofighi, and F., Vafaei, "Evaluation of Dike-type Causeway Impacts on the Flow and Salinity Regimes in Urmia Lake, Iran," *Journal of*



Great Lakes Research 35/1, 2009, pp. 13-22.